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The Response of Dairy Calves to Rumen Inoculation and Various Feeding Methods

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Introduction

THERE is conflict in the recommendations for the supplemental feeding of dairy calves during the first few months of their lives. In addition to the feeding of milk, some authorities advocate feeding of hay alone, others the feeding of concentrates alone, in contrast to the normal methods of feeding some of both.

The importance of rumen microorganisms for the health and well-being of the ruminant is well known. It is also well known that the type of feed consumed greatly affects the character of the rumen microflora. As yet, however, the most beneficial types of organisms necessary for the well-being of the ruminant and the feeding practices which will perpetuate these organisms are not fully known.

Review of Literature

Hungate (6), Johnson *et al.* (8), and Lardinois *et al.* (9) present evidence that the microorganisms of the rumen (anaerobic bacteria and protozoa) function in the digestion of cellulose, and conversion of urea and ammonium bicarbonate into proteins, and in raising the protein quality of the vegetable proteins. These proteins become available to the host when the microorganisms themselves are digested (13). A number of investigators (1,5,7,9,10,11) point out that rumen microorganisms contribute to the synthesis of water soluble vitamins in the paunch.

Several investigators (3,4,18,20) have made contributions to the present knowledge of rumen microorganism types and species. Although this information is limited, it is sufficient to provide means of measuring rumen population. Precise information on the identity of the organisms that promote healthy rumen function is needed.

A number of workers (2,8,12,16) have presented evidence that the numbers and types of microorganisms are related closely to the kind of feed consumed. Pounden and Hibbs (14,15,16,17) have published considerable literature on cud inoculation and the growth of young calves under several types of feeding and conclude that the rumen population

associated with rations of hay and pasture are markedly different from those found in calves fed large quantities of concentrates. In their early reports they did not find it possible to relate the well-being of the calves with the presence or absence of characteristic microorganisms, but in later reports they state that rumen inoculations resulted in the development of satisfactory microflora and fauna in a short period, with considerable improvement in thrift of the animals.

Research workers of a commercial feed company (19) found that larger calves were developed up to four months of age when they were given no hay during the first two months. Of course, elimination of hay from the ration until that age resulted in higher consumption of concentrates.

Additional information is needed concerning the economy, as well as the growth rate, of calves fed at various levels of roughages and concentrates and the role of rumen microorganisms in the nutrition of calves.

Objectives of Study

A project was undertaken at the West Virginia University Agricultural Experiment Station to study the influence of three feeding methods on the growth, thrift and rumen microorganisms of calves and the effect of cud inoculation under each of the feeding practices.

Procedure

The calves used were of three dairy breeds (Ayrshire, Holstein, and Jersey) from the West Virginia University herd. They were removed from their dams before nursing and placed into individual pens for the entire experimental period. There was no direct contact between animals, and insofar as practical, an attempt was made to avoid possibility of natural inoculation by workers in the feeding and care of the calves and in the cleaning of the pens.

The calves were allotted to the three groups as evenly as possible as to breed, birth weight, and sex. The feeding schedule included an average of 315 pounds of whole milk per calf, fed during a period of eight weeks. The dam's colostrum was fed during the first four days. Supplemental feed for each group was as follows:

Group A (Normal Group)—Hay at will. Starter at will up to four pounds daily.

Group B (Starter Group)—Starter at will up to four pounds daily. No hay during the first eight weeks. Hay during the second eight weeks limited to one-half amount consumed by Group A during the second eight weeks.

Group C (Hay Group)—Hay at will. No starter during the first eight weeks. Starter during the second eight weeks limited to one-half amount consumed by Group A.

The hay was early cut, green, containing more grasses than legumes. The starter was a nationally-known commercial mixture containing no antibiotics. During the last two to four weeks of the trial most of the calves would have consumed more starter ration than was allowed them.

Eighteen calves were divided into three groups as equal as possible as to sex and breed and placed on the study for a 16-week period each year during three successive years. One-half of the calves (three in each group) were inoculated each week during the first six weeks following birth, and again on the ninth week, with a cud portion secured fresh from a healthy cow.

All calves were weighed and measured for height at withers each week. The circumference of heart girth and paunch was measured at four-week intervals. In addition, notes were taken as to general vigor, occurrence of scours, and the age at first-observed rumination.

A sample of the rumen contents was secured by the use of a stomach tube from each calf previous to the weekly inoculation during the first six weeks and until protozoa were found. Rumen samples were also secured from all calves on the 9th and 15th weeks. The samples were placed into tightly-stoppered glass bottles, protected from the cold and light, and examined microscopically within an hour. Counts on the number of bacteria and protozoa were made.

In preliminary work leading to this study calves were inoculated weekly with frozen rumen juice which had been taken from a healthy cow. The juice was collected as soon as possible following slaughter, frozen, kept in a deep freeze, and thawed shortly before inoculation was to be made. Apparently all protozoa were killed by the freezing process since none were recovered alive in the thawed juice. This preliminary work was of considerable value in developing and standardizing techniques and practices. For example, considerable difficulty was encountered in obtaining the rumen samples from certain of the calves until a satisfactory plastic tube was found. It may be of interest to add that the results of this preliminary work agree closely with those obtained with the use of fresh cud portions as the inoculant.

Results and Discussion

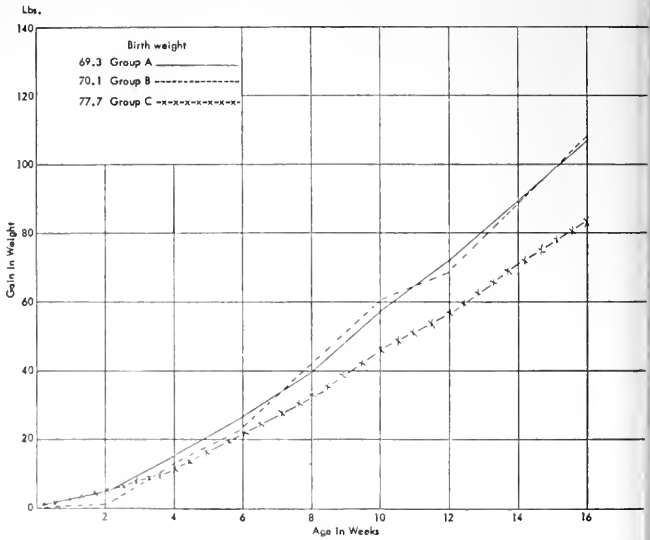
EFFECT OF THE FEEDING METHOD ON GROWTH

The calves in Group A and B gained almost the same amount in weight during the 16 weeks of the experiment. They were both fed starter ration at will up to four pounds per day. However, Group A

received hay at will during the entire 16 weeks, whereas Group B received no hay during the first eight weeks and only half as much during the second eight weeks as the calves in Group A consumed. Group C calves received hay at will, no starter during the first eight weeks, and half the amount of starter ration fed Group A during the second eight weeks, and grew at a slower rate during the period of this study. Graph 1 shows the growth of the calves on each feeding method. A complete table of the individual calves is given in the appendix (Table 1).

Analysis of the data (see appendix, Table 3) reveals that the feeding regime had a very highly significant effect of gain in body weight.

The average amount of feeds consumed per calf in each group during the three yearly trials is shown on page 7. (See Table 2 in the appendix for complete individual figures.) Group B consumed an average of only ten pounds more starter ration while eating 57 pounds less hay than Group A, so that the total cost and the cost per pound of gain were very nearly the same. Although Group C had a somewhat lower total feed cost due to less starter ration consumed, their cost per pound of gain was slightly higher than with the other methods of feeding.



GRAPH 1. Effect of feeding method on gain in weight (average of three years)

FEED CONSUMED, COST, POUND GAIN AND COST PER POUND GAIN ON THREE FEEDING METHODS

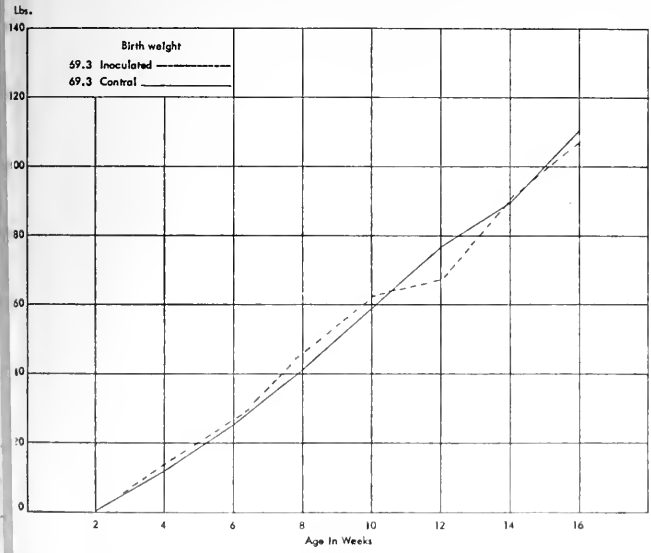
Group	Number of Calves	Milk lb.	Starter lb.	Hay lb.	Cost* $	Gain lb.	Feed Cost* Per Pound Gain Cents
A	17	312.6	240.6	144.2	32.93	109.0	30.2
B	17	315.2	250.3	87.3	32.54	106.6	30.5
C	18	316.0	107.7	200.3	26.25	82.2	31.9

*Cost figures used: Milk, $5 cwt.; Starter Ration, $6 cwt.; Hay, $2 cwt.

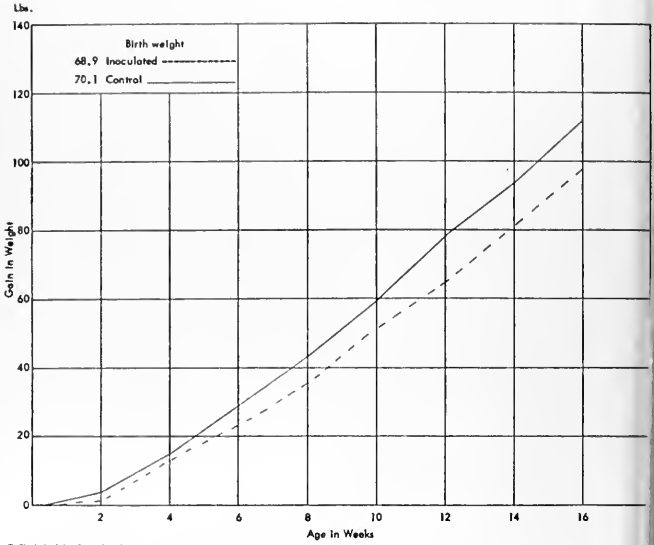
The young calf raised with a limited amount of whole milk and given a plentiful supply of starter ration will make more rapid gains than when starter ration is limited. The feeding of roughage seems to be of little value during the first two months following birth.

INFLUENCE OF CUD INOCULATION ON GROWTH

The average gain in weight from birth to 16 weeks for inoculated and uninoculated calves under the three methods of feeding tested are shown in Graphs 2, 3, and 4. Graph 5 shows the gain for all inoculated compared with all control animals, with all feeding methods thrown together.



GRAPH 2. Gain in weight—Group A (average of three years).



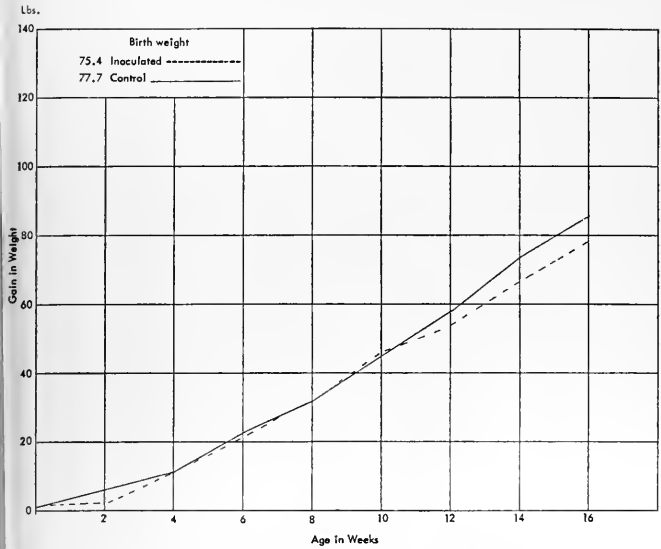
GRAPH 3. Gain in weight—Group B (average of three years).

Analysis of the data (appendix) shows that cud inoculation has no significant effect on gain in body weight. No interaction was observed between feeding regime and cud inoculation.

Although not statistically significant, the control animals did make somewhat greater gains, under each method of feeding, than the animals which were inoculated. Growth, as measured by heart girth, paunch and height at withers, also slightly favored the control calves. Table in the appendix gives the individual growth data.

EFFECTIVENESS OF CUD INOCULATION IN ESTABLISHING PROTZOA IN THE RUMEN

Placing a small fresh cud portion obtained from a healthy cow into the back of the mouth of the calf so that it would be swallowed proved an effective and simple way to implant protozoa and other organisms into the rumen. During each year of the trial, at least two-thirds of the rumen samples of all inoculated calves were found to contain protozoa the first week following the initial inoculation, and all samples obtained from inoculated calves contained the organisms following the second inoculation. When protozoa were once found in the rumen, subsequent samples from the calf always contained the organism.



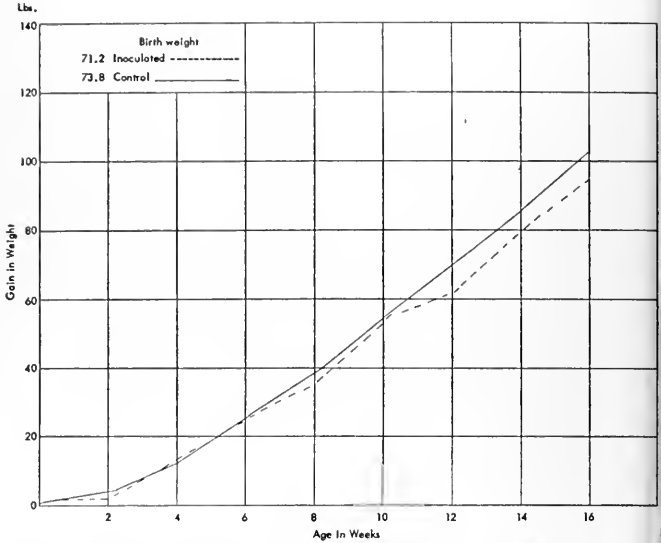
GRAPH 4. Gain in weight—Group C (average of three years).

EFFECTIVENESS OF PREVENTING THE PRESENCE OF PROTOZOA IN THE RUMEN UNDER MANAGEMENT CONDITIONS DESIGNED TO PRECLUDE NATURAL INOCULATION

Management practices, as stated previously, were designed to prevent the natural inoculation of the calves. The calves were maintained in individual, solid partitioned, wooden pens high enough to prevent contact. In feeding, and in the cleaning of pens, a definite attempt was made to avoid carry-over of any materials and, in taking the rumen samples, the control animals were always sampled first, with an individual sterilized plastic tube used for each animal.

The fact that during each of the three years at least half of the control animals showed protozoa in their rumen by the seventh week following birth indicates that under ordinary feeding and management conditions calves would become naturally inoculated at an early age and that the artificial inoculation, while effective, would be of no consequence.

During the second year of the trials, one uninoculated calf (110 I.M.) did not show protozoa in a rumen sample until the 11th week, and another (95H.F.) until the 15th week. During the final year, un-



GRAPH 5. Gain in weight—all Groups (average of three years).

inoculated calf 680J.F. showed no protozoa until the 17th week, and samples from the rumen of 682J.F. showed no protozoa until the 20th week. These latter two animals were continued past the close of the trial until they did show protozoa to determine how long they could be continued protozoa free. Differences in their growth and consumption of feed are not sufficient to determine whether or not the lack of protozoa was a detriment.

EFFECT OF INOCULATION ON START OF RUMINATION

Complete data are available on the age of first-observed rumination during the second year of the trials.

AVERAGE AGE AT FIRST-OBSERVED RUMINATION

	INOCULATED CALVES		CONTROL CALVES	
Group	Average Days of Age	Youngest and Oldest Age	Average Days Of Age	Youngest and Oldest Age
A	37	(28-47)	23.5	(17-30) (2 only
B	30	(26-33)	28.3	(24-33)
C	32.7	(25-47)	32.7	(17-43)
Average All	33.2		28.7	

This indicates that neither feeding method nor the cud inoculation of young dairy calves hastens the onset of rumination. An attempt was made to correlate the presence of protozoa in the rumen with the onset of rumination. However, no indication of a correlation was found.

It appears that the type of feed consumed, or the inoculation by cud portions from a healthy cow have little effect upon the age at first rumination which usually starts during the fourth or fifth week.

Several calves were observed "pseudo-ruminating" during the first few days following birth. In none of these observations, however, was a true cud found.

OBSERVATIONS ON THE MICROBIOLOGY OF THE RUMEN

Rumen samples of calves usually contained numerous gram positive and gram negative cocci. Present less often were streptococci and gram positive long rods.

All samples contained large numbers of microorganisms. As the number of protozoa increased, there was usually some decrease in the bacterial numbers. A bacteria count of 50 to 100 ($x10^6$) was usual for the first six weeks and about 30 to 40 ($x10^6$) at 14 to 16 weeks.

Summary and Conclusions

Calves started on a limited amount of whole milk grew more rapidly when fed with a good supply of starter ration than when hay was fed free will and starter ration withheld. The results do not indicate a need for roughage during the first two months following birth. An analysis of the data indicates that the feeding regime has a highly significant effect on gain in weight.

Although oral cud inoculation of the young calf with a fresh cud portion from a healthy cow is highly effective in permanently implanting protozoa into the rumen of the calf, it seems evident that under normal conditions of feeding and management the calf would become naturally inoculated within a few weeks following birth. Inoculation failed to show an advantage under any of the three different feeding practices studied. Analysis of the data shows that no significant effect in gain or loss in weight was due to the inoculation and that there was no interaction between feeding regime and incoculation.

Rumination usually started during the fourth or fifth week following birth regardless of the type of feed consumed or whether or not the calf was inoculated.

No benefit due to the inoculation of calves with a cud portion from a healthy cow was found under the three systems of feeding tested in this study involving 27 inoculated calves compared with 27 uninoculated animals.

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APPENDIX

TABLE 1. INCREASE IN SIZE OF HEART GIRTH, PAUNCH AND WITHERS AND GAIN IN WEIGHT FROM BIRTH TO 16 WEEKS OF INDIVIDUAL CALVES ON THREE DIFFERENT FEEDING METHODS

INOCULATED					CONTROL				
GROUP AND YEAR	HEART (IN.)	PAUNCH (IN.)	WITHERS (CM.)	WEIGHT (LBS.)	GROUP AND YEAR	HEART (IN.)	PAUNCH (IN.)	WITHERS (CM.)	WEIGHT (LBS.)
A—1952-53					A—1952-53				
88H.F.	11.5	18.0	17.0	115	86H.F.	13.5	22.5	16.0	134
665J.F.	10.25	16.0	17.5	79	664-J.F.	12.5	18.5	16.0	106
686A.M.	13.5	22.5	15.5	138	685A.M.	9.25	17.0	12.0	77
Av. 52-53	11.75	18.8	16.67	110.7	Av. 52-53	11.83	19.3	14.67	105.7
A—1953-54					A—1953-54				
673J.F.	9.875	17.0	11.2	79	674J.F.	9.5	17.0	10.0	81
712A.M.	9.0	14.0	7.5	75	713A.F.	Removed from project—died			
93H.F.	9.0	14.5	12.0	87	115H.M.	12.0	19.0	12.0	121
Av. 53-54	9.258	15.17	10.2	80.3	Av. 53-54	10.75	18.0	11.0	101
A—1954-55					A—1954-55				
683J.F.	9.5	18.0	16.0	110	680J.F.	12.5	21	15	113
684J.F.	14	23.5	17	127	682J.F.	12.5	19	15	95
100H.F.	16.5	16.5	17	156	101H.F.	17	18	22	155
Av. 54-55	13.3	19.3	16.7	130.7	Av. 54-55	14.0	19.3	17.3	121
B—1952-53					B—1952-53				
87H.F.	12.5	18.5	13.5	135	85H.F.	12.5	16.5	19.0	137
683A.M.	10.5	18.5	14.0	84	682A.M.	10.5	19.0	16.0	116
668J.F.	13.0	17.5	12.0	80	666J.F.	13.0	20.5	19.0	114
Av. 52.53	12.0	18.17	13.17	99.9	Av. 52-53	12.0	19.0	18.3	122.3

Table 1 (continued)

Inoculated					Control				
Group and Year	Heart (in.)	Paunch (in.)	Withers (cm.)	Weight (lbs.)	Group and Year	Heart (in.)	Paunch (in.)	Withers (cm.)	Weight (lbs.)
B—1953-54					B—1953-54				
708.A.M.	9.5	16.5	14	95	709A.M.	9.25	14.25	10.0	98
109H.M.	8.5	17	10	78	110H.M.	7.5	12.5	9.2	73
675J.F.	9	13.25	15.2	73	677J.F.	9.5	14.75	12.0	90
Av. 53-54	9.03	15.58	13.07	82	Av. 53-54	8.75	13.8	10.4	87
B—1954-55					B—1954-55				
394J.M.	13.5	19	17	121	396J.M.	14.75	22	16	123
123H.M.	10.75	18	15	122	124H.M.	12.5	21.5	17	159
737A.M.	10	17	15	101	681J.F.	Died from effects of dehorning			
Av. 54-55	11.4	18	15.7	114.7	Av. 54-55	13.6	21.75	16.5	141
C—1952-53					C—1952-53				
96H.M.	11.0	16.5	18.5	78	95H.M.	12.5	21.5	14.5	118
684A.M.	7.0	16.5	10.5	60	681H.M.	8.0	15.0	11.0	72
381J.M.	9.5	18	12	77	380J.M.	9.0	15.5	11.5	58
Av. 52-53	9.17	17.0	13.7	71.7	Av. 52-53	9.83	17.3	12.3	82.7
C-1953-54					C-1953-54				
107H.M.	7.5	13.5	8	68	95H.F.	6.25	14	8.7	76
710A.M.	6.5	12.375	10	74	711A.M.	8.75	18	8.3	77
388J.M.	7.5	16.5	9	71	389J.M.	6	14.75	8.5	61
Av. 53-54	7.2	14.125	9	71	Av. 53-54	7	15.58	8.5	71.3
C—1954-55					C—1954-55				
126H.M.	9	17	11	98	125H.M.	11.5	21.25	13	120
738A.M.	5.5	15	14	84	736A.M.	8.5	14	12	91
397J.M	9	16.5	10	87	398J.M.	12	22.5	15	111
Av. 54-55	7.75	16.17	11.67	89.7	Av. 54-55	10.67	19.27	13.3	107.3

(Summary of Table 1)
Yearly and Three-Year Average Gains

Inoculated						Control					
Group and Year	Heart (in.)	Paunch (in.)	Withers (cm.)	Weight (lb.)	Gain per Day	Group and Year	Heart (in.)	Paunch (in.)	Withers (cm.)	Weight (lb.)	Gain per Day
A—52-53	11.75	18 8	16.67	110.7	1.05(3)	A—52-53	11.83	19.3	14.67	105.2	1.00(3)
53-54	9.26	15.17	10.2	81.3	.77(3)	53-54	10.73	18	11	101	.95(2)
54-55	13.3	19.3	16.7	130.7	1.24(3)	54-55	14	19.3	17.3	121	1.15(3)
3 yr. av.	11.436	17.76	14.52	107.5	1.02(9)	3 yr. av.	12.19	18.89	14.32	110.5	1.05(8)
B—52-53	12	18.17	13.17	99.8	.95(3)	B—52-53	12.0	19	18 3	122.3	1.16(3)
53-54	9.03	15.58	13.07	82.6	.78(3)	53-54	8.75	13.8	10.4	87	.83(3)
54-55	11.4	18.0	15.7	114.7	1.09(3)	54-55	13.6	21.75	16.5	141	1.34(2)
3 yr. av.	10.81	17.28	13.98	98.9	.94(9)	3 yr. av.	11.45	18.18	15.1	113.7	1.08(8)
C—52-53	9.17	17.0	13.7	71.7	.68(3)	C—52-53	9.83	17.33	12.3	82.7	.787(3)
53-54	7.2	14.12	9.0	71.0	.67(3)	53-54	7.0	15.58	8.5	71.3	.67(3)
54-55	7.75	16.17	11.67	89.7	.87(3)	54-55	10.67	19.27	13.3	107.3	1.02(3)
3 yr. av.	8.04	15.77	11.46	77.4	.73(9)	3 yr. av.	9.17	17.39	11.37	87.1	.829(9)
3 yr. av. all groups	10.09	16.93	13.32	94.5	.90(27	3 yr. av. all groups	10.94	18.15	13.60	104.1	.99(25)

Table 2. Feed Consumed, Cost, and Cost Per Pound of Gain of Dairy Calves from Birth to 16 Weeks of Age on Three Feeding Methods

Inoculated						Control					
Group	Milk (lbs.)	Starter (lbs.)	Hay (lbs.)	Total Cost ($)	Cost Per Pound of Gain	Group	Milk (lbs.)	Starter (lbs.)	Hay (lbs.)	Total Cost ($)	Cost Per Pound of Gain
A						A					
88H.F.	338.3	266.5	83.0			86H.F.	348.5	266.0	76.1		
665J.F.	292.5	177.6	111.8			664J.F.	278.5	216.2	92.1		
686A.M.	303.1	238.4	94.3			685A.M.	305.9	162.6	141.7		
Av 52-53	311.3	227.5	96.4	31.14	.2805(3)	Av 52-53	310.9	214.9	103.3	30.50	.2877(3)
A						A					
673J.F.	284.0	178.8	78.6			674J.F.	287.0	197.6	158.9		
712A.M.	298.0	294.0	146.8			713A.F.	Removed from project—died				
93H.F.	350.0	201.9	194.2			115H.M.	326.5	259.3	160.3		
Av 53-54	314.0	194.9	139.9	30.9	.3773(3)	Av 53-54	306.7	228.4	151.6	32.29	.3197(2)
A						A					
683J.F.	298	287.9	162.3			680J.F.	300	273.8	166.7		
684J.F.	294	287.2	187.3			682J.F.	301	227.6	129.4		
100H.F.	351	311.2	236.6			101H.F.	349	323	230.4		
Av 54-55	314.4	299.4	195.4	37.58	.2868(3)	Av 54-55	316.7	274.8	175.5	35.83	.2961(3)
B						B					
87H.F.	346	295.2	44.9			85H.F.	350	319.1	59.5		
683A.M.	312.2	197.3	30.7			682A.M.	297	239.7	39.8		
668J.F.	307	155	64.4			666J.F.	293.5	289.3	32.6		
Av 52-53	321.7	215.8	46.7	29.96	.2996(3)	Av 52-53	313.5	282.7	43.9	33.51	.2747(3)

(continued on next page)

Table 2 (continued)

Inoculated						Control					
Group	Milk (lbs.)	Starter (lbs.)	Hay (lbs.)	Total Cost ($)	Cost Per Pound of Gain	Group	Milk (lbs.)	Starter (lbs.)	Hay (lbs.)	Total Cost ($)	Cost Per Pound of Gain
B						B					
708A.M.	295	235	80.1			705A.M.	288	112.4	104.7		
109H.M.	327.5	219.1	64.0			110H.M.	348.5	240	83.2		
675J.F.	271.5	200.4	87.9			677J.F.	293	237.9	78.8		
Av 53-54	301.3	218.2	77.0	29.69	.3577(3)	Av 53-54	309.8	196.8	88.9	29.08	.3342(3)
B						B					
394J.M.	300	285.7	135.4			396J.M.	300	289.9	112.6		
123H.M.	362	304.9	157.2			124H.M.	357	319.9	158.4		
737A.M.	300	310.1	155.3			681J.F.	Died from effects of dehorning				
Av 54-55	320.7	300.2	149.5	37.03	.3220(3)	Av 54-55	328.5	304.9	135.5	36.95	.2605(2)
C						C					
96H.M.	341	106.5	185.3			95H.M.	350.5	116.5	219.6		
684A.M.	307.5	113.5	80.9			681A.M.	314.5	105	164.8		
381J.M.	306.8	109	132.2			380J.M.	303	108	110		
Av 52-53	318.4	109.7	132.8	25.16	.3494(3)	Av 52-53	322.7	109.8	164.8	25.96	.3127(3)
C						C					
107H.M.	349	68.5	153			95H.F.	352	101	211.7		
710A.M.	285	91.5	142.3			711A.M.	299	93	202.5		
388J.M.	289	98.5	180.4			389J.M.	295	116	156.6		
Av 53-54	307.7	86.2	158.6	23.72	.3340(3)	Av 53-54	315.3	103.3	190.3	25.77	.3629(3)
C						C					
126H.M.	357	116	298.3			125H.M.	355	117	348		
738A.M.	307	117	239.1			726A.M.	298	118	305.6		
397J.M.	290	121.2	221.8			398J.M.	290	124	255.8		
Av 54-55	318	118.1	253.1	28.05	.3317(3)	Av 54-55	314.3	119.7	303.1	28.95	.2706(3)

(Summary of Table 2)
Three-Year Average

Inoculated						Control					
Group	Milk (lbs.)	Starter (lbs.)	Hay (lbs.)	Total Cost ($)	Cost Per Pound of Gain	Group	Milk (lbs.)	Starter (lbs.)	Hay (lbs.)	Total Cost ($)	Cost Per Pound of Gain
A	313.1	240.4	143.9	32.96	.3071(9)	A	312.0	240.8	144.5	32.94	.2981(8)
B	314.6	244.7	91.1	32.23	.3262(9)	B	315.9	256.0	83.7	32.83	.2861(8)
C	314.7	104.6	181.4	25.64	.3313(9)	C	317.4	110.9	219.3	26.91	.3096(9)
Over-all average	314.1	196.6	138.8	30.24	.3200(27)	Over-all average	315.1	204.6	149.2	30.89	.2967(25)

Feed costs used:

Milk—$5.00 per cwt.
Starter—$6.00 per cwt.
Hay—$2.60 per cwt.

Table 3. Analysis of Variance

Source	Degrees of Freedom	Sums of Squares	Mean Square	F
Feeding regimes	2	10,222.70	5,111.35**	12.131
Inoculations	1	510.30	510.30	1.211
Years	2	11,626.82	5,813.41**	13.797
Feeding by inoculation Interaction	2	1,789.15	894.58	2.123
Error	34	14,326.00	421.35	

**P<.01